LOCAL SYSTEM EFFECTS

Testimony of Mark Hesters, Ajoy Guha, Ty Larson, Jeff Miller and Al McCuen

INTRODUCTION

This testimony was jointly prepared by the California Energy Commission (CEC) and California Independent Operator (Cal-ISO) and provides an analysis of the local system effects of the Potrero 7 Power Plant Project (Unit 7) and our conclusions regarding these effects. Local system effects are the localized electrical benefits and impacts that can be attributed to the addition of a new generator to the grid. The effects assessed in this testimony include the potential to defer capital investments, the effect on system losses, the impact on operational reliability and flexibility and the ability to integrate Unit 7 into the existing and planned system.

The evaluation of local system effects has been included to provide a greater understanding of the effect of the addition of Unit 7 to the grid. Conformance with reliability criteria is addressed in the Transmission System Engineering testimony and the System Reliability testimony of the Cal-ISO.

Generally, there are two ways to supply power to the San Francisco peninsula. Power may be produced locally, or power may be produced remotely and shipped into the area on transmission facilities. The amount of power that can be supplied from remote locations is limited by the capacity of the transmission facilities serving the area. Unit 7, if approved and built, would inject as much as 615[1] megawatts of real power and 400 megavars of reactive power (MVAR) into the grid, which in turn would help maintain the ability to supply all of the electrical load within the Bay Area [2]. As a result, Unit 7 plays a key role (along with future transmission upgrades) in the long-term plan to retire older unreliable Bay Area power plants. The addition of Unit 7 will also reduce system losses and increases operational flexibility and reliability.

SUMMARY OF CONCLUSIONS

1. When comparing the addition of Unit 7 against importing additional power into the San Francisco Area, Unit 7 will substantially reduce transmission system losses. Over 20 years, the savings to ratepayers have a present value at between $55 million and $80 million. In addition to the savings associated with avoiding these transmission losses would also decrease the use of fossil fuels, water, and the production of air emissions.

---

[1] According to Mirant's preliminary interconnection study the maximum net output of the proposed Unit 7 is 615 MW.

[2] In general, electrical energy defined by "Real power" measured in megawatts is used to supply lighting, motors, computers and numerous other appliances. "Reactive power" measured in megavars supplies voltage support to transport the energy through the electrical transmission system. Real power flow on transmission facilities must not exceed the capability of the transmission facilities. When real power flow is projected to exceed the capability of transmission facilities, either steps must be taken to limit the power flow, or additional or higher capacity equipment must be installed. If reactive power is insufficient, system voltages will decrease, which could lead to the controlled dropping of customer loads (rolling blackouts) and even the uncontrolled loss of load associated with voltage collapse.

2. Unit 7 represents a significant source of real and reactive power to serve loads in the immediate San Francisco Peninsula Area; such resources substantially reduce the need to import power over already stressed transmission facilities. Note that if the Hunters Point Power Plant were retired after Unit 7 is added, the addition of Unit 7 would not defer any currently planned transmission facilities. Instead, Unit 7 may offset the need for other additional transmission reinforcements (beyond those already in the Pacific Gas & Electric Company (PG&E) transmission plan). Unit 7 will displace significant transmission upgrades that would be required to maintain reliability if Hunters Point Power Plant is retired without the addition of new generation in San Francisco such as Unit 7.

3. A primary benefit of the addition of Unit 7 is that it would add generation that is much more reliable and environmentally benign than the generation that is currently in place in the San Francisco Peninsula. Because of their age, existing generating units within the San Francisco Peninsula are unreliable and it is uncertain how much longer they can continue to operate. Moreover, the units are either run-time limited or de-rated (in terms of maximum output) due to emission output limitations and will likely require further upgrades to remain in operation in coming years.

4. Unit 7's additional generation will provide greater flexibility within the Bay Area for the Cal-ISO, PG&E, and generation owners to schedule maintenance on transmission facilities and generating units. Also, during periods of high demand, Unit 7 will provide critically needed real and reactive power margin that will increase the operator's ability to manage adverse and unexpected conditions.

LAWS, ORDINANCES, REGULATIONS AND STANDARDS (LORS)

Where appropriate, the authors have utilized Western States Coordinating Council (WSCC), National Energy Reliability Council (NERC), and Cal-ISO Grid Planning Standards to assess the benefits or detriments of the addition of Unit 7.

To ensure that energy implications are considered in project decisions, the California Environmental Quality Act (CEQA) guidelines require that environmental analysis include a discussion of the potential energy impacts of proposed projects with particular emphasis on avoiding or reducing inefficient, wasteful, and unnecessary consumption of energy. The guidelines also require that the decision-maker consider "[t]he effects of the project on local and regional energy supplies and on requirements for additional capacity, …" (CEQA Appendix F).

SETTING AND AREA RESOURCES

The San Francisco Peninsula area is composed of the City of San Francisco and the area between the San Mateo substation and San Francisco. Major transmission feeds the area through the San Mateo and Martin substations, which connect to the 230kV system (see Figure 1). The 2001 demand forecast for a 1-in-10 year adverse weather condition in 2004 is approximately 1,400 MW for the San Francisco Peninsula area (see the **ALTERNATIVES** section of this document). Power is supplied to the San Francisco Peninsula area by generation located in the area and major transmission lines shipping power into the area.

GENERATION

The forecasted total local generation in year 2004 is 598 MW (363 MW from Potrero Power Plant and 215 MW from Hunters Point Power Plant).

LOCAL SYSTEMS EFFECTS Table 1
San Francisco Peninsula Generation

Plant	Unit	Size (MW)	Fuel Type	In-Service Date	Operating Restrictions
Potrero	3	207	Natural Gas	1965	Bay Area NOx restrictions
	4	52	Distillate	1976	877 hours/year
	5	52	Distillate	1976	877 hours/year
	6	52	Distillate	1976	877 hours/year
Hunters Point	1	52	Distillate	1976	877 hours/year
	2*	0	None	1948	(107 MVAR)
	3*	0	None	1949	(107 MVAR)
	4	163	Natural Gas	1958	Bay Area NOx restrictions
United Cogen	1	20	Natural Gas	1986	None

* Hunters Point units 2 and 3 are now operating as synchronous condensers.

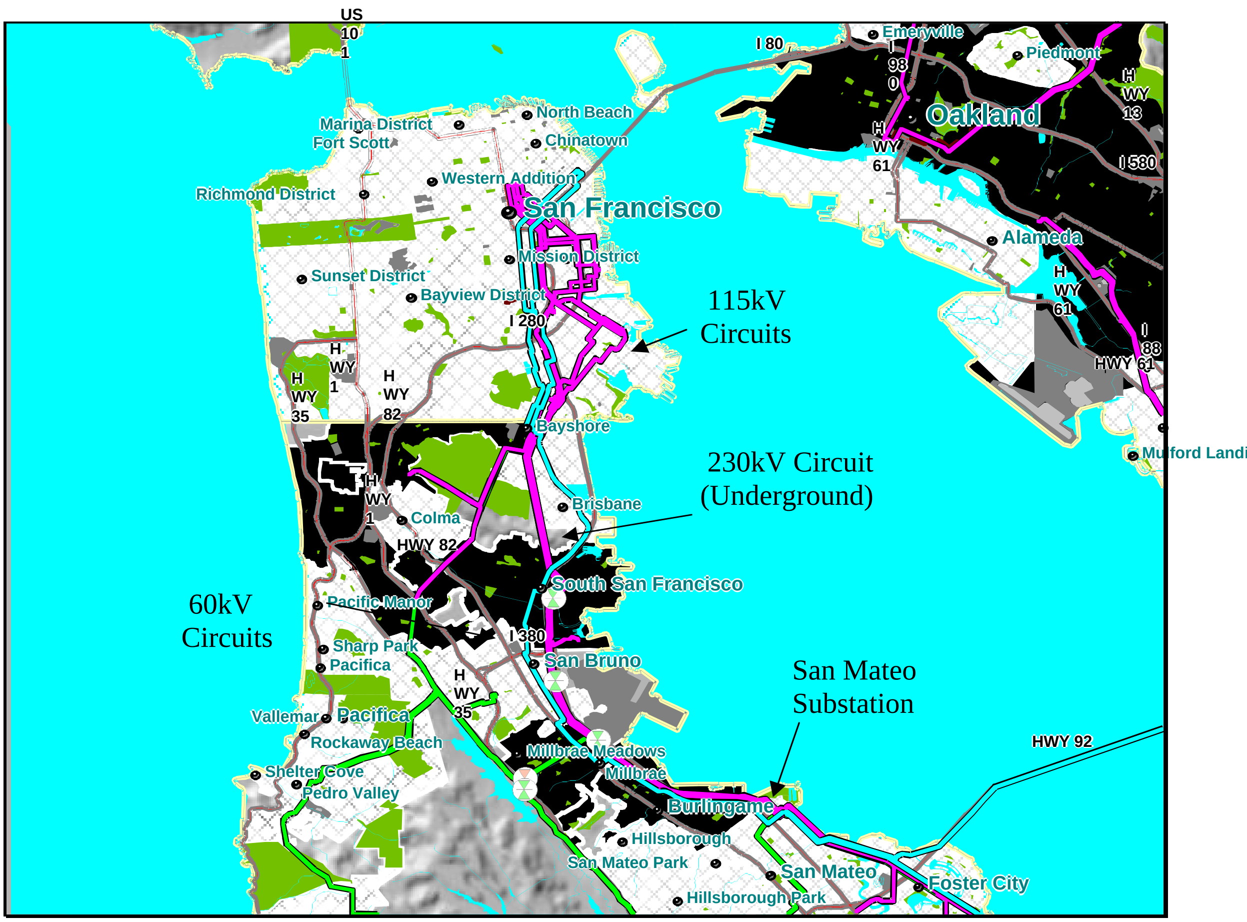
The existing generation in San Francisco is highly vulnerable. The Potrero and Hunters Point power plants are old and exhibit frequent outages. The units at these plants are unreliable enough that the Cal-ISO generally assumes that two units from these plants will be unavailable at any given time. The largest and most critical generating unit on the peninsula is Potrero Unit 3 (a steam thermal generating unit) which began operating in 1965 and is significantly beyond the expected 30-year life of a power plant of this type. Hunters Point Unit 4 is 44 years old. Both Potrero Unit 3 and Hunters Point Unit 4 will require significant upgrades over the coming years to be able to meet diminishing NOx emission limitations.

Potrero Power Plant Units 4, 5, and 6 (156 MW) and Hunters Point Unit 1 are combustion turbines that operate on distillate fuel with high air pollution emissions. These turbines are restricted in operation to only 877 hours per year (or about ten-percent of the year) each due to air district permits. There is also an existing agreement between the City and County of San Francisco and PG&E that calls for the shut down of the Hunters Point Power Plant when that plant is no longer needed for reliability.

TRANSMISSION

The San Francisco Peninsula receives its power from three sources. Part of the demand is served by power generated locally by San Francisco generation units. Approximately another third of the power needed for the San Francisco Peninsula is served by power delivered at San Mateo Substation from 230kV transmission lines connecting the Tesla, Newark, and Ravenswood Substations. The remaining San Francisco Peninsula demand is met through power delivered to San Mateo Substation via two 230kV lines crossing San Francisco Bay. Power flows northward along the Peninsula from San Mateo Substation to Martin Substation through the combination of one 230kV transmission line, five 115kV lines, and one 60kV line (see Figures 1&2).

LOCAL SYSTEM EFFECTS Figure 1
Geographical Map of the San Francisco and Peninsula Corridor Area[3]

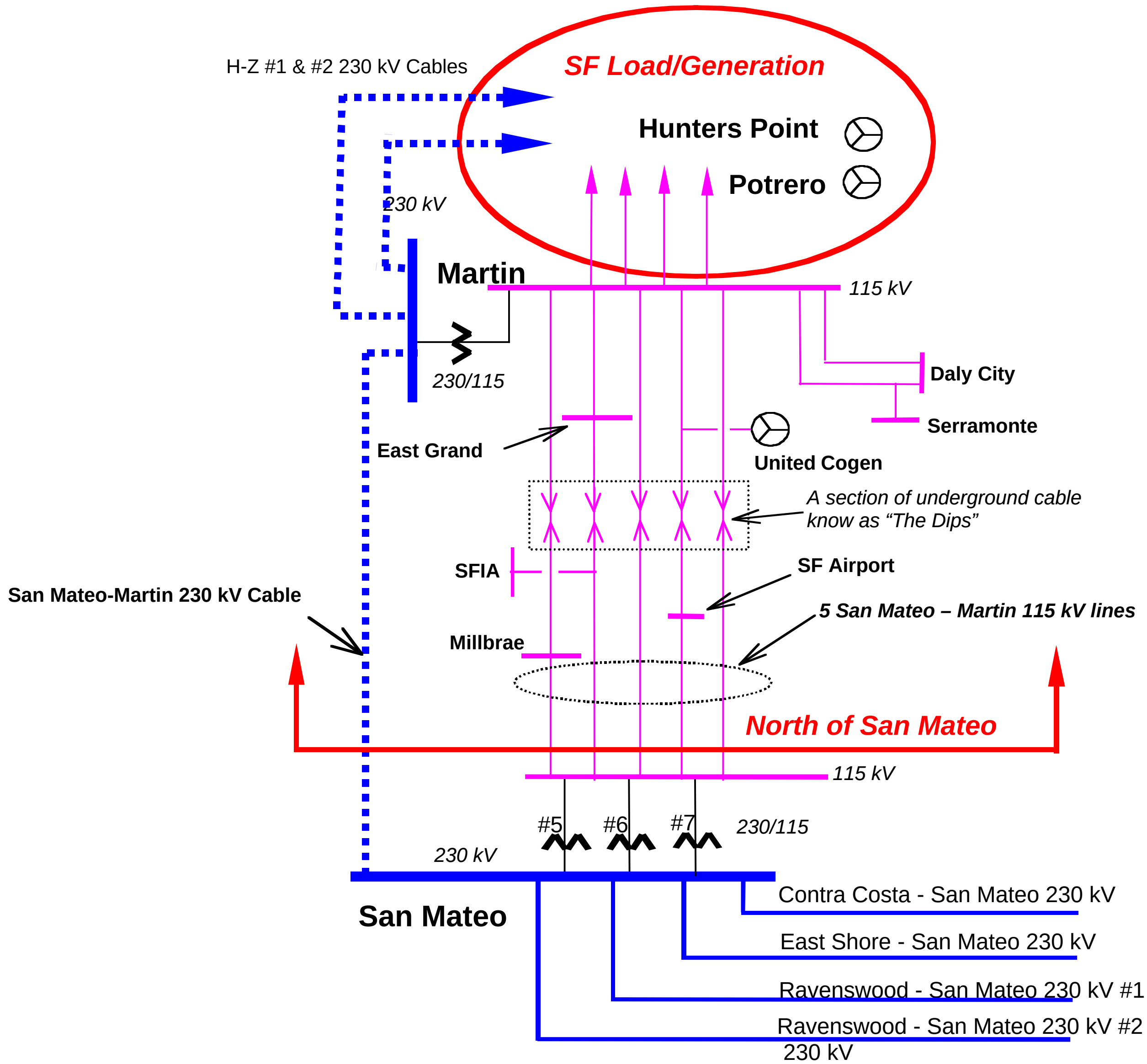


Synchronous condensers located at the Hunters Point Power Plant are used to maintain voltage in the area. Numerous small shunt capacitors are also used within the local electric distribution system to maintain voltage by supplying reactive power support. Reactive power support cannot be transmitted over long distances and needs to be provided locally. While it is possible to operate a system devoid of local generation, in San Francisco's case, this would require substantial new transmission lines to import the required quantity of power and additional local voltage support devices (i.e., synchronous condensers, shunt capacitors, etc.).

---

[3] PG&E, San Francisco Peninsula Long-Term Electric Transmission Planning Study, Page 11.

LOCAL SYSTEM EFFECTS Figure 2
Sketch of San Francisco Peninsula Transmission System



MAXWELL ORDINANCE

An important consideration in determining the benefits of Unit 7 is the Maxwell Ordinance, which was approved by the San Francisco Board of Supervisors on May 29, 2001. This ordinance sets several requirements for City staff to consider to support the permitting of Unit 7. Briefly these requirements are:

- Hunters Point Power Plant will cease operation as a fossil generation plant within 90 days after Unit 7 is placed in service.
- Potrero Power Plant Units 4 through 6 will be retrofitted or rebuilt with the best available pollution control technology (BACT) and will operate only during specified times.

- Potrero Power Plant Unit 3 will shut down as soon as it is no longer needed to sustain electric reliability in San Francisco. (CCSF Ord, Pages 2-4).

LOCAL SYSTEM EFFECTS

The following types of local system effects have been reviewed to assess the potential benefits of local generation:

1. **The Effect on Plans for Transmission Facility Upgrades:** Bringing Unit 7 online could defer or delay the need for capital facilities (transmission lines, capacitors and other system improvements) needed by the electric system to meet reliability planning standards.
2. **The Effect on System Losses:** Comparing the system with and without Unit 7 interconnected and operating identifies the increase or decrease in electricity losses.
3. **The Effect on Operational Reliability and Flexibility:** Operational reliability includes an evaluation of whether or not Unit 7 would provide increased or decreased operational flexibility and reliability and a general discussion of Unit 7's possible effect on reliability must-run (RMR) costs (see Definition of Terms).
4. **Ability to be integrated into existing and planned system:** Would major system additions or system modifications be needed to accommodate the new facility?

THE EFFECT ON PLANS FOR TRANSMISSION FACILITY UPGRADES

As stated earlier, power is supplied to customers on the San Francisco Peninsula either through local generation or through transmission facilities that run in a northward loop along the Peninsula from the San Mateo Substation. Therefore, additional generation on the Peninsula can reduce the need for additional transmission facilities into the Peninsula. To determine the need for these new facilities, we must first determine the amount of generation that can be assumed available in planning studies.

The Cal-ISO Grid Planning Standard requires that the system be able to supply all electric loads in an area during the combined outage of the most critical single transmission line and the most critical generating unit. In addition, in the Bay Area, the grid planning standards require that the system be able to supply all electric needs with one of the 52 MW combustion turbine units on the Peninsula removed from service as well. Before the addition of Potrero Unit 7, the most critical single unit outage would be Potrero Unit 3 (207 MW). After the addition of Unit 7, the most critical outage would be Unit 7 (615 MW)[4].

[4] Currently the total outage of Potrero Unit 7 is considered a single contingency because a common mode failure for the plant has been identified (the condenser). This determination (to consider Potrero Unit 7 a single contingency) could change if the plant is reconfigured to eliminate the common mode of failure or if it is determined that a condenser failure is sufficiently unlikely and can be disregarded for planning purposes. The Cal-ISO has encouraged Mirant to reconfigure the plant so that the common mode(s) of failure are eliminated and therefore the likelihood of an entire plant outage is reduced.

In applying the planning standards, the amount of generation that can be assumed to be operating on the Peninsula before the addition of Unit 7 is 339 MW (Potrero Units 4, 5, and 6, Hunters Point Unit 4, and United Cogen). If it is assumed that the Hunters Point units are retired after the addition of Unit 7, then the amount of generation that can be assumed to be operating on the Peninsula for Grid Planning studies is 331 MW (Potrero Units 3, 4, & 5 and United Cogen). Therefore, because of its design with a credible single point of failure, the addition of Potrero Unit 7 decreases the amount of generation that we can assume available for planning the system by 8 MW.

A plan for transmission upgrades to the Bay Area system was developed prior to the addition of Potrero Unit 7. The San Francisco Study Group (a group of stakeholders including PG&E, the Cal-ISO, the City and County of San Francisco, and other interested stakeholders) completed this plan in October 2000. To address the problems identified in the studies, the following additions were required:

1. Upgrade the San Mateo – Martin #4 60kV circuit to 115kV.
2. Reconductor the underground "dips" of the 115kV lines between San Mateo and Martin Substation.
3. Add a new 2.4-mile Hunters Point-Potrero 115kV underground cable
4. Add a new 25-mile 230kV transmission line from the Jefferson substation to Martin substation which includes the following transmission system changes:
    a. Rebuild an existing 60 kV double circuit tower line from Jefferson Substation to Sneath Lane to a 230 kV double circuit tubular steel pole line. String one position with 2-1113 kcmil AAL conductors for 230 kV operation and the other position with 1-1113 kcmil AAL conductor for 60 kV operation.
    b. Install a new 400 MVA, 230kV underground cable approximately 8 miles between Sneath Lane and Martin Substations.
    c. Construct a new transition station near Sneath Lane Substation for overhead to underground transition.
    d. Install one 230 kV line position at Jefferson to accommodate 2-1113 kcmil AAL conductors per phase. Install the necessary equipment to operate the Jefferson 230 kV bus as a ring bus.
    e. Install two 60 kV line positions at Sneath Lane, Carolands, and Ralston to accommodate one 1113 kcmil AAL conductor/phase. All of these substations will be looped. Crystal Spring Substation will be tapped off the new Jefferson-Sneath Lane 60 kV circuit.
    f. Install one 60 kV line position at Millbrae.
    g. Build a 60 kV line section between the new line position and tower _ of the Millbrae tap. This would allow the Millbrae tap to be unparalleled and looped off the Jefferson-Sneath Lane 60 kV circuit.
    h. Replace motor-operated switches at Pacifica and Half Moon Bay with 60 kV breakers. These breakers would operate normally closed.

i. Reconductor San Mateo to Burlingame 60 kV section of the San Mateo-Martin Circuit 4 from 4/0 Cu to 477 SSAC.

The first three projects are likely to be completed before Unit 7 is operating. The Jefferson-Martin 230kV line is currently scheduled to be in place in 2005 (assuming it is approved by the CPUC). With these four transmission projects and other system reinforcements, the San Francisco Peninsula region is projected to meet reliability standards through the year 2009. This assumes that Potrero 3 will remain in-service through 2009 and will be retrofitted to meet emission requirements by the end of 2004.

In addition to the above-mentioned projects, there is another transmission project currently sponsored by the City and County of San Francisco. This project involves the construction of a second 2.4-mile Hunters Point - Potrero 115 kV underground cable. While this project is driven in part by other needs, it also supports the addition of Unit 7. The Cal-ISO, PG&E, and other members of the San Francisco Study Group agree that this second cable is necessary for the operation of Unit 7.

The replacement of the Hunters Point Power Plant with Unit 7 would decrease the amount of generation in the area that can be assumed in planning the system by about 8 MW. This small change in the amount of generation that can be assumed in planning studies is not sufficient to change the timing or scope of the transmission upgrades currently planned for the San Francisco Peninsula.

The current plan is predicated on the continued availability of the existing generating units within the San Francisco area. Recent history has shown that the output of the existing generating units could be significantly limited by Bay Area NOx limitations and frequent maintenance outages. Concerns associated with the availability of generation from the existing Potrero and Hunters Point power plants are discussed in greater depth in the section on “System Operation Benefits.”

While adding Unit 7 would not change the current plan for transmission system additions, Unit 7 would provide long-term benefits. In the long-term, the existing generation at Hunters Point and Potrero will either be retired or will require significant upgrades. Retiring generation at Hunters Point and Potrero will lead to the need for local resources (generation, load reductions) or major new transmission facilities. The addition of Unit 7 could eliminate the need to undertake one of the following:

1. add more generation in San Francisco or the Peninsula;
2. Significantly upgrade/retrofit existing Potrero Power Plant generation units; or
3. Add transmission facilities.

THE EFFECT ON SYSTEM LOSSES

Transmission system losses are a function of generation schedules, imports, exports, wheeling and system loop flow in addition to load. Transmission line losses occur as a result of conductor resistance and corona discharge. Resistance line losses are significant, especially on long, heavily loaded lines with a high load factor (75% - 100%).

Typical values for utility systems in California range from 12 kW/mile to 500 kW/mile for line loadings between 25% and 100% of the conductor ratings. Resistance line losses are generally described as I2R heating dissipation losses. These losses are similar to the operation of electric strip heaters for home and building use where heat is produced by connecting a resistor heating element across 120V or 240V, and allowing the current to flow through the resistor element.

Based on the predicted 2004 northern California system peak demand of 27,300 MW, the primary system losses (transmission lines and transformers) are approximately 889 MW without Unit 7 operating[5]. Transmission losses thus constitute 3.3% of the predicted system peak demand.

Transmission line losses were assessed for six dispatch scenarios. These dispatch scenarios were selected to bracket the range of dispatch conditions that occur in an actual year. Because the power supplied to the system must equal the system load plus the losses, when Unit 7 operates, 615 MW of generation as shown by the dispatch scenarios must be reduced to balance the additional 615 MW from Unit 7. The baseline for comparison was the system losses without Unit 7. Losses with Unit 7 on line and other units re-dispatched according to the established dispatch scenarios were then compared to the baseline.

The following dispatch scenarios were studied for the year 2004 to allow for the addition of the 615 MW Unit 7:

1. Moss Landing down 352 MW, Helms down 263 MW;
2. Moss Landing down 615 MW;
3. La Paloma down 615 MW;
4. Pittsburg down 500 MW, Contra Costa down 115 MW;
5. Sutter down 525 MW, Rio Linda down 90 MW; and
6. Northwest Imports down 615 MW.

By adding Unit 7 and reducing generation as depicted in Dispatch Scenarios 1-6, system peak loss reductions range between 42 MW and 102 MW for the different scenarios (See LSE Table 2 at the end of this document). This is a substantial system benefit, effectively increasing power supplies without the use of fuel or water and without producing any additional plant additions.

To estimate the annual energy savings we assigned probabilities to the various dispatch scenarios tested. Multiplying the unique dispatch-related loss values by the assigned dispatch probability provided an expected overall MW loss value for each study year: e.g. 58 MW in 2004. The estimated annual energy savings that correspond to the expected overall system loss reduction values noted above are 156 GWh in year 2004. These amounts of energy savings are equivalent to the annual energy requirement for

[5] For the case without Potrero Unit 7, Hunters Point was assumed to be operating, and vice-versa.

approximately 22,000 homes. A reduction in system losses of this magnitude would save ratepayers $5 to $8 million per year. Over a twenty-year period, the present value of these savings to ratepayers is $55 to $80 million. In calculating these values for the loss savings, the following assumptions were made:

- Burner-tip natural gas prices are $4 - $5/MMBtu;
- The displaced unit's heat rate is 12,000 – 13,000 Btu/kWh;
- Any emissions offsets created were valued at $0 (a very conservative assumption); and
- The rate of return is 8%.

The calculations for this analysis are contained in Appendix 1 for study year 2004.

To ensure that energy implications are considered in project decisions, environmental documents must include a discussion of the potential energy impacts of proposed projects. This discussion should emphasize avoiding or reducing inefficient, wasteful and unnecessary consumption of energy and the project's effect on local and regional energy supplies. Most decision-makers generally are faced with projects having only negative energy use implications because most projects result in significant increases in the use of energy. This Commission faces a different situation in that Unit 7 will substantially reduce energy losses while providing numerous benefits. If one anticipates that Unit 7 would operate for at least 20 years there are substantial long-term environmental benefits related to reduced fuel and water use and to reduced emissions due to the reduction in electricity system losses.

SYSTEM OPERATIONAL RELIABILITY AND FLEXIBILITY BENEFITS

Operational Reliability and Flexibility

As described earlier, the existing generation in San Francisco is highly vulnerable. The existing Potrero and Hunters Point Power Plants are beyond their projected service lives and tend to have frequent outages. Moreover, the plants face increasing challenges in meeting NOx limitations that are scheduled to be reduced over coming years.

Potrero Unit 3 (a steam thermal generating unit) began operating in 1965 and is significantly beyond the expected 30-year service life of a power plant of this type. Hunters Point Unit 4 is 44 years old. Due to their age, these plants tend to break down and require significant amounts of maintenance. The reliability of these units has increasingly worsened, often portions of the plant(s) are curtailed or out of service.

Power plant de-rates challenge local area operations, and place an undue strain on already stressed transmission facilities. It is not uncommon to find more than one San Francisco area resource off-line and unavailable at any given time. Absent this local generation, it is often extremely difficult, if not impossible, to take existing transmission equipment out-of-service to perform planned maintenance or construction. Forced outages of transmission equipment with reduced local generation can lead to significantly reduced reliability (an increased likelihood of involuntary local area load shedding or rolling blackouts).

In addition, Potrero Unit 3 and Hunters Point Unit 4 are subject to NOx emission limitations that are slated to be reduced over the coming three years. Both these units are subject to a NOx emissions "bubble" that applies to the boilers owned by Mirant and PG&E, respectively, in the greater Bay Area. The bubble requires owners to operate their fleet of boilers to meet an average NOx output level that will decrease in the next few years as follows:

2002 = 47 parts-per-million (ppm)
2003 = 47 ppm
2004 = 31 ppm
2005 and beyond = 15 ppm

Currently, the output from Potrero Unit 3 has been limited by Mirant due to the NOx emission bubble, pending NOx reduction upgrades to the remaining fleet of Mirant boilers. Hunters Point Unit 4 is undergoing upgrades that should allow it to operate within the bubble through 2003. The ongoing availability of these units in the next three years depends on the success of NOx reduction upgrades currently underway or planned. Moreover, it is expected that significant upgrades to Hunters Point Unit 4 and Potrero Unit 3 will be required if these plants are to continue to operate, particularly in 2005 and beyond. As stated earlier, most of the remaining generation in San Francisco and the Peninsula are combustion turbines (Potrero Units 4, 5, 6, and Hunters Point Unit 1) which are each only allowed to operate 877 hours per year.

Thus, in the short term, the availability of generating resources critical to reliability in San Francisco and the Peninsula is contingent upon successful NOx reduction projects either already underway or planned in the next few years.

The unavailability of existing generating units in San Francisco (units unavailable due to breakdowns or curtailed due to NOx limitations) is increasingly limiting the operational flexibility of the grid and compromising reliability. Because Unit 7 would be a new plant and would operate well within local NOx emission limitations, Unit 7 is expected to provide greater reliability and flexibility for operators of the ISO controlled grid. For example, under partial load conditions, Unit 7's additional generation will provide greater flexibility within the Bay Area for the ISO, PG&E, and generation owners to maintain transmission facilities and generating units. Similarly, during periods of high demand, Unit 7 will provide critically-needed real and reactive power margin and flexibility to operate the grid reliably under adverse and unexpected conditions, for example, the unexpected high temperatures combined with unforeseen extended maintenance outages that were experienced in the Bay Area on June 14, 2000.

Reliability Must Run (RMR) Costs

The Cal-ISO is currently undertaking a project for Market Design (MD 2002). As part of this project, the Cal-ISO is looking at new ways to procure the local area reliability services that it currently procures via Reliability Must Run (RMR) contracts. Until the method for procuring local area reliability services is determined it is impossible to state with certainty the impact of Unit 7 on RMR costs.

If the Cal-ISO were to maintain its current practice of executing RMR contracts with generators in specific areas with both market power problems and reliability concerns, the addition of Unit 7 would likely result in reduced RMR variable costs, although the impact on RMR fixed costs is uncertain. Currently, the RMR owners are paid the difference between their variable operating costs and market prices, and some proportion of their fixed costs through the RMR contract, depending on the type of RMR contract selected by the unit owner. Because Unit 7 would be a new, efficient plant, it is likely that even if all the units at the Potrero Power Plant continue to be under RMR contracts, total RMR variable cost payments would likely be reduced by the presence of Unit 7. The impact of Unit 7 on fixed cost payments under the RMR contracts is more difficult to predict because the proportion of fixed costs reimbursable under the RMR contract may vary from year to year according to the contract type selected by the plant owner. There is additional uncertainty because the type of RMR contract most likely to be selected by Mirant for Unit 7 is currently awaiting a final decision from the Federal Energy Regulatory Commission.

RESPONSES TO COMMENTS ON THE DRAFT LSE SECTION

POTRERO BOOSTERS & NEIGHBORHOOD ASSOCIATION (PBNA)

PBNA-LSE-1: The PBNA has several concerns about the reliability implications of the proposed configuration of Unit 7. The PNBA is concerned that the loss of the steam turbine will result in the loss of the entire facility. They would also like to see the plant designed so that it can operate with greater flexibility.

Responses: Staff agrees with the PNBA concerns about plant reliability and is especially concerned with the impact this has on system planning. As currently designed Unit 7 can operate the gas turbines when the steam turbine is unavailable, although gas turbine output may be lower than the rated capability when the steam turbine is unavailable. The critical components in the current design of Unit 7 are the condenser and cooling systems because the failure of either component will require the entire plant to shut down. There is some debate about whether or not these components represent a credible point of failure. Other plants in California are designing condenser and cooling systems with redundant components so that the loss of either is an incredible or very unlikely event. Staff is currently considering recommending that the condenser and cooling be designed with these redundant components.

CITY AND COUNTY OF SAN FRANCISCO (CCSF)

CCSF-LSE-1: The draft LSE did not address the potential benefits of alternatives to Unit 7 in the LSE analysis.

Response: The potential benefits of alternatives to Unit 7 were not evaluated in the LSE analysis. The LSE analysis focuses on the proposed project. However, a similarly sized power plant located elsewhere in San Francisco would provide similar benefits.

CCSF-LSE-2: The draft LSE is vague on the status of the Hunters Point Power Plant.

Response: The final LSE analysis assumes the Hunters Point Power Plant would shut down when Unit 7 begins operating.

CCSF-LSE-3: The current design of Unit 7 with two modes of failure (the condenser and cooling system) raises significant policy and reliability concerns. Including impacts on the need for Potrero Unit 3.

Response: Please see the reponse to **PBNA-LSE-1** above.

CCSF-LSE-4: The system loss benefits are significant, overstated and will not have a significant impact on electricity rates.

Response: The LSE uses a gas price that could be considered high relative to today's prices, however the benefits are estimated for 2005 through 2025. Saving ratepayers a million dollars is a benefit whether or not it has a significant impact on rates. The LSE assumed Potrero Unit 3 is available in the loss analysis. Assuming that Potrero Unit 3 is not available would most likely increase system losses and possibly the loss benefits of Unit 7. The RMR cost implications of Unit 7 are discussed in the LSE analysis and are too uncertain to predict.

CCSF-LSE-5: The discussion on operational reliability did not include enough information to support the conclusions. There are a series of questions about the schedule for NOx reduction upgrades to Mirant boilers and implications of the NOx bubble on the Potrero Unit 3 RMR contract.

Response: The purpose of the NOx retrofit and NOx bubble discussion in the operational flexibility section was to highlight the fact that the existing plants in San Francisco are old, unreliable and require significant upgrades to keep running. Current schedules for retrofits do not impact the operational flexibility that a plant like the proposed Unit 7 will provide.

CCSF-LSE-2: The studies used to analyze Unit 7's integration into the existing and planned electric system assumed the Hunters Point Power Plant was shut down when Unit 7 begins operation.

Response: The Draft System Impact Study completed in June of 2001 analyzed the impacts of Unit 7 with the Hunters Point Power Plant operating. The study also included the 595 MW United Golden Gate Power Plant (UGGPP). One line overload (San Mateo - Belmont 115 kV) was identified in the draft study however this overload is not expected without the UGGPP, which is not currently moving forward. All other overloads can be mitigated with special protection schemes or by accelerating the construction of the Hunters Point to Potrero 115 kV cable. Thus, even with Hunters Point operating Unit 7 can be into the existing system without significant downstream facilities.

CONCLUSIONS

1. Unit 7 represents a significant source of real and reactive power to serve loads in the immediate San Francisco Peninsula Area; such resources substantially reduce the need to import power over already-stressed transmission facilities. If Hunters Point Power Plant is retired after Unit 7 is added, the addition of Unit 7 will not lead to the deferral of any currently planned transmission facilities.

2. The addition of Unit 7 will substantially reduce transmission system losses. Over 20 years, the estimated savings to ratepayers have a present value at between $55 million and $80 million. As well as reducing the cost of producing power in California, these loss savings would also contribute to a related decrease in the use of fossil fuels, water, and the production of air emissions by reducing the need for additional generation resources.

3. A primary benefit of the addition of Unit 7 is that it would add generation that is much more reliable and environmentally benign than the generation that is currently in place in the San Francisco Peninsula. Because of their age, existing generating plants on San Francisco Peninsula are unreliable and it is uncertain how much longer they can continue to operate. Moreover, the units are either run-time limited or de-rated (in terms of maximum output) due to emission output limitations and will likely require further upgrades to remain in operation in coming years.

4. Unit 7's additional generation will provide greater flexibility within the Bay Area for the Cal-ISO, PG&E, and generation owners to schedule maintenance on transmission facilities and generating units. Also, during periods of high demand, Unit 7 will provide critically needed margin [see comments above] and the flexibility to maintain reliability under adverse and unexpected conditions.

5. Unit 7 can be connected to the Cal-ISO Controlled Grid with the projects identified in the current transmission plan and the generator interconnection studies.

REFERENCES

PG&E (Pacific Gas & Electric), San Francisco/Peninsula Technical Study: Year 2004 Transmission System Thermal Analysis, November 1999.

CCSF (City and County of San Francisco). CCSF Ord. Final CCSF Ordinance of May 29, 2001. Submitted to California Energy Commission, June 12, 2001.

Mirant (Mirant Corp) System Impact/Facilities Study, Potrero Power Plant Unit 7 Project, supersedes draft dated June 29, 2001, September 2001.

LOCAL SYSTEM EFFECTS Table 2
POTRERO 7 LOSS ANALYSIS-YEAR 2004
Total Northern California System Losses / System Loss Reduction

	SYSTEM PEAK LOSS PRE-PROJECT (MW)	SYSTEM PEAK LOSS WITH POTRERO 7 UNITS (MW)	SYSTEM PEAK LOSS REDUCTION (MW)	PROBABILITY OF THE REDISPATCH SCENAIRIO	EXPECTED PEAK LOSS REDUCTION (MW)	SYSTEM ANNUAL LOAD FACTOR	EQUIVALENT HOURS LOSS FACTOR	ANNUAL ENERGY SAVED (GWh)	PROBABLE ANNUAL ENERGY SAVED (GWh)	ADJUSTMENT FACTOR FOR REMOTE DISPATCH	EXPECTED ANNUAL ENERGY SAVED (GWh)
se Dispatch, PG&E sessment 2004 Summer ak, Swing= Morro Bay unit Potrero 7 units are off line.	889.24										
spatch 1, Local Adjustment otrero 7= +615 MW, Duke oss= -352 MW, Helms= - 3 MW		821.48	67.76	0.18	12.20	0.57	0.34	199.92	35.99	1.00	35.99
spatch 2, Local Adjustment otrero 7= +615 MW, Moss nding= -615 MW		834.56	54.68	0.18	9.84	0.57	0.34	161.33	29.04	1.00	29.04
spatch 3, Local Adjustment: trero 7= +615 MW, La loma= -615 MW		831.25	57.99	0.18	10.44	0.57	0.34	171.10	30.80	1.00	30.80
spatch 4, Local Adjustment: trero 7= +615 MW, tsburg= -500 MW, Contra sta= -115 MW		846.23	43.01	0.18	7.74	0.57	0.34	126.90	22.84	1.00	22.84
spatch 5, Local Adjustment: trero 7= +615 MW, Sutter= 25 MW, Rio Linda= -90 MW		846.79	42.45	0.18	7.64	0.57	0.34	125.25	22.54	1.00	22.54
spatch 6, Remote justment: Potrero 7= +615 V, COI= -615 MW		787.57	101.67	0.10	10.17	0.57	0.34	299.97	30.00	0.50	15.00
tals:				1.00	58.03				171.21		156.21
erage:			61.26					180.74			--

NOTE: Calculations for expected MW Peak loss & Energy savings and related present value in dollars are illustrated in Appendix G-1

DEFINITION OF TERMS

AAC	All Aluminum conductor.
ADR	Alternative Dispute Resolution
Ancillary Services Market	The market for services other than scheduled energy that are required to maintain system reliability and meet WSCC/NERC operating criteria. Such services include spinning, non-spinning, replacement reserves, regulation (AGC), voltage control and black start capability.
Ampacity	Current-carrying capacity, expressed in amperes, of a conductor at specified ambient conditions, at which damage to the conductor is nonexistent or deemed acceptable based on economic, safety, and reliability considerations.
Ampere	The unit of measure of electric current; specifically, a measure of the rate of flow of electrons past a given point in an electric conductor such as a power line.
Available Transmission Capacity (i.e., ATC)	Available Transmission Capacity in any hour is equal to Operational Transmission Capacity for that hour minus Existing Transmission Contracts for that same hour (ATC = OTC - ETC). (See the other definitions below).
Breaker	Circuit breaker - An automatic switch that stops the flow of electric current in a suddenly overloaded or otherwise abnormally stressed electric circuit.
Bundled Conductor	Two or more wires, connected in parallel through common switches, that act together to carry current in a single phase of an electric circuit.
Bus	Conductors that serve as a common connection for multiple transmission lines.
Cal-ISO	California Independent System Operator - The Cal-ISO is the FERC regulated control area operator of the Cal-ISO transmission grid. Its responsibilities include providing non-

	discriminatory access to the grid, managing congestion, maintaining the reliability and security of the grid, and providing billing and settlement services. The Cal-ISO has no affiliation with any market participant.
Cal-ISO Controlled Grid	The combined transmission assets of the Participating Transmission Owners (PTOs) that are collectively under the control of the Cal-ISO.
Cal-ISO Reliability Criteria	Reliability standards established by the NERC, WSCC, and the ISO, as amended from time to time, including any requirements of the NRC.
Cal-ISO Planning Process	Annual studies conducted by the PTO's and Cal-ISO in an open stakeholder process. These studies determine the future transmission reinforcements necessary to enable the ISO Controlled Grid to meet the ISO Reliability Criteria. The Cal-ISO Planning Process also includes studies of new resource connections and third party proposals for new additions to the ISO Controlled Grid.
Cal-ISO Tariff	Document filed with the appropriate regulatory authority (FERC) specifying lawful rates, charges, rules, and conditions under which the utilities provide services to parties. A tariff typically includes rate schedules, list of contracts, rules, and sample forms.
Capacitor	An electric device used to store charge temporarily, generally consisting of two metallic plates separated by a dielectric.
Cogeneration	The consecutive generation of thermal and electric or mechanical energy.
Conductor	The part of the transmission line (the wire) which carries the current.
Congestion	The condition that exists when market participants seek to dispatch in a pattern which would result in power flows that cannot be physically accommodated by the system. Although the system will not normally be operated in an overloaded condition, it may be described as congested based on requested/desired schedules.

Congestion Management	Congestion management is a Cal-ISO scheduling protocol that is used to resolve Congestion.
Contingency	Disconnection or separation, planned or forced, of one or more components from the electric system.
Day-Ahead Market	The forward market for the supply of electrical power at least 24 hours before delivery to Buyers and End-Use Customers.
Demand	Load plus any exports from an electric system.
Demand Forecast	An estimate of demand (electric load) over a designated period of time.
Dispatch	The operating control of an integrated electric system to: (i) assign specific generators and other sources of supply to effect the supply to meet the relevant area Demand taken as Load rises of falls; (ii) control operations and maintenance of high voltage lines, substations, and equipment, including administration of safety procedures; (iii) operate interconnections (iv) manage energy transactions with other interconnected Control Areas; and (v) curtail Demand.
dV/dQ	The partial derivative of the voltage at a bus with respect to the reactive injection at that bus. (See any elementary college calculus text for further discussion of partial derivatives.) The point at which dV/dQ approaches infinity is defined as the point of voltage collapse.
Emergency Condition	The system condition when one or more system elements are forced (not scheduled) out of service.
Emergency Overload	Loading of a transmission system element above its Emergency Rating during an Emergency Condition.
Emergency Rating	A special rating established for short-term use in the event of a forced line or transformer outage (e.g., an emergency). An emergency rating may be expressed as a percentage of the normal

	rating (e.g., 115 percent of normal) or as an elevated current rating. For example, the normal rating for a conductor may be 1000 amperes and the emergency rating may be 1100 amperes.
Excessive Voltage Deviation	A sudden change in voltage at any substation as a result of a Contingency that exceeds established allowable levels of change.
Existing Transmission Contract (i.e., ETC)	A contract for transmission services that was in place prior to the start of ISO operations.
Fault Duty	The maximum amount of short-circuit current which must be interrupted by a given circuit breaker.
FERC	Federal Energy Regulatory Commission
General Order 95	California Public Utilities Commission (CPUC) General Order which specifies transmission line clearance requirements.
Generation Outlet Line	Transmission facilities (circuit, transformer, circuit breaker, etc.) linking generation to the main grid.
Generation Tie	Transmission facilities (circuit, transformer, circuit breaker, etc.) linking generation to the main grid.
Generator	A machine capable of converting mechanical energy into electrical energy.
Heat Rate	The amount of energy input to an electric generator required to obtain a given value of energy output. Usually expressed in terms of British Thermal Units per kilowatt hour (Btu/kWh).
Hour-Ahead Market	The electric power futures market that is established 1-hour before delivery to End-Use Customers.
Imbalance Energy	Energy not scheduled in advance that is required to meet energy imbalances in real-time. This energy is supplied by Participating Generators under the Cal-ISO's control, providing spinning and non-spinning reserves,

replacement reserves, and regulation, and other generators able to respond to the Cal-ISO's request for more or less energy.

Interconnected System Reliability	See Reliability.
Kcmil or kcm	One thousand circular mils. A unit of the conductor's cross sectional area which, when divided by 1,273, gives the area in square inches.
Kv	Kilovolt - A unit of potential difference, or voltage, between two conductors of a circuit, or between a conductor and the ground.
Load	The rate expressed in kilowatts, or megawatts, at which electric energy is delivered to or by a system, or part of a system to end use customers at a given instant or averaged over an designated interval of time. (Also see Demand.)
Load Factor	The average Load over a given period (e.g., one year) divided by the peak Load in the period.
Loop	An electrical connection where a line is opened and a new substation is inserted into the opening. A looped configuration creates two lines, one from each of the original end points to the new substation. A looped configuration is more reliable than a tap configuration because the looped configuration provides two lines into the substation rather than just one in a tap configuration. Also, see Tap below.
Low Voltage	Voltage at any substation that is below the minimum acceptable level.
Marginal Unit	The Generator (or Load) that sets the market clearing price in the ISO's Ancillary Services Market (or the Power Exchange's energy market). The marginal unit is the Generator or Load that had the highest accepted bid for energy or Demand reduction.
MVAr	Megavar - One megavolt ampere reactive (a measure of reactive power). Reactive power demand is generally associated with motor loads and generation units or static reactive sources

	must supply this demand in the system.
MVA	Megavolt ampere - A unit of apparent power: equal to the product of the line voltage in kilovolts, the current in amperes, and the square root of 3 divided by 1000.
MW	Megawatt - A unit of power equivalent to 1,341 horsepower.
NERC	North American Electric Reliability Council
Nominal Voltage	Also known as Normal Voltage. The voltage at which power can be delivered to loads without damage to customer equipment or violation of Cal-ISO Reliability Criteria when the system is under Normal Operation.
Normal Operation	When all customers receive the power they are entitled to without interruption and at steady voltage, and no element of the transmission system is loaded beyond its continuous rating.
NRC	Nuclear Regulatory Commission
N-1 Contingency	A forced outage of one system element (e.g., a transmission line or generator).
N-2 Contingency	A forced outage of two system elements usually (but not exclusively) caused by one single event. Examples of an N-2 Contingency include loss of two transmission circuits on a single tower line or loss of two elements connected by a common circuit breaker due to the failure of that common breaker.
Operational Transfer Capability (i.e., OTC)	The maximum amount of power which can be reliably transmitted over an electrical path in conjunction with the simultaneous reliable operation of all other paths. This limit is typically defined by seasonal operating studies, and should not be confused with a path rating. Also referred to as OTC.
Outlet	Transmission facilities (circuit, transformer, circuit breaker, etc.) linking generation to the main grid.
Participating Generator	A generator that has signed an agreement with the Cal-ISO to abide by the rules and conditions

	specified in the Cal-ISO Tariff.
Participating Transmission Owner (i.e., PTO)	A Participating Transmission Owner is an electric transmission owning company that has turned over operational control of some or all of their electric transmission facilities to the Cal-ISO. Currently, the three Participating Transmission Owners are PG&E, SCE, and SDG&E.
Path Rating	The maximum amount of power which can be reliably transmitted over an electrical path under the best set of conditions. Path ratings are defined and specified in the WSCC Path Rating Catalog.
PG&E	Pacific Gas & Electric Company
PG&E Interconnection Handbook	Detailed instructions to new customers (either load or generation) on how to interconnect to the PG&E electric system.
Post-Transient Voltage Deviation	The change in voltage from pre-contingency to post-contingency conditions once the system has had time to readjust.
Power Flow	A generic term used to describe the type, direction, and magnitude of actual or simulated electrical power flows on electrical systems.
Power Flow Analysis	A power flow analysis is a forward looking computer simulation of all major generation and transmission system facilities that identifies overloaded circuits, transformers and other equipment as well as system voltage levels under both Normal and Emergency Conditions.
Pump	A hydroelectric generator that acts as a motor and pumps water stored in a reservoir to a higher elevation.
Q/V Curve	A graphical representation of the voltage a given substation bus as a function of the reactive injection at that bus.
RAS	Remedial Action Scheme - An automatic control provision (e.g., trip a generation unit to mitigate a circuit overload).

Reactive Power	The portion of apparent power that does no work in an alternating current circuit but must be available to operate certain types of electrical equipment. Reactive Power is most commonly supplied by generators or by electrostatic equipment, such as shunt capacitors.
Reactive Margin	Reactive Power must be available at all load buses to prevent voltage collapse. Reactive margin is the amount of additional reactive load, usually measured in MVAR's, which may be added at a particular bus before the system experiences voltage collapse.
Reactor	An electric device used to store electric current temporarily, generally consisting of a coil of wire wound around a magnetic core.
Real Power	Real power is the work-producing component of apparent power and is required to operate any electrical equipment that performs energy conversion. Examples of this electrical equipment would be a heater, a lamp, or a motor. Real power is usually metered in units of kilowatt-hours (kWh).
Real-Time Market	The competitive generation market controlled and coordinated by the Cal-ISO for arranging real-time imbalance power.
Reconductor	The removal of old conductors on a transmission or distribution line followed by replacement of these conductors with new higher capacity conductors.
Reliability	The degree of performance of the elements of the bulk electric system that results in electricity being delivered to customers within accepted standards and in the amount desired. May be measured by the frequency, duration, and magnitude of adverse effects on the electric supply.
Reliability Criteria	Principals used to design, plan, operate, and assess the actual or projected reliability of an electric system.
Reliability Must-Run (i.e., RMR)	The minimum generation (number of units or MW output) required by the Cal-ISO to be on

	line to maintain system reliability in a local area.
SCE	Southern California Edison Company
SDG&E	San Diego Gas and Electric Company
Sensitivity Study	An analysis to determine the impact of varying one or more parameters on the results of the original analysis.
Series Capacitor	A static electrical device that is connected in-line with a transmission circuit that allows for higher power transfer capability by reducing the circuit's overall impedance.
Shunt Capacitor	A static electrical device that is connected between an electrical conductor and ground. A shunt capacitor normally will increase the voltage on a transmission circuit by providing reactive power to the electrical system.
Single Contingency	See N-1 Contingency.
Solid Dielectric Cable	Copper or aluminum conductors that are insulated by solid polyethylene type insulation and covered by a metallic shield and outer polyethylene jacket.
Source or Sink of Reactive Power	A source of Reactive Power is a device that injects reactive power into the power system (e.g., a Generator or a Capacitor). A sink of Reactive Power absorbs reactive power from the power system. Examples of reactive power sinks are shunt Reactors and motor loads.
Static Compensator	StatCom - a shunt connected power system device that includes Capacitors and Reactors controlled by solid state electronic devices as opposed to mechanically operated switches.
Substation	An assemblage of equipment that switches, changes, or regulates voltage in the electric transmission and distribution system.
Switchyard	A substation that is used as an outlet for one or more electric generators.
Switched Reactive Devices	A shunt Capacitor or shunt Reactor controlled by mechanically operated switches.

Switching Station	Similar to a substation, but there is only one voltage level.
Synchronous Condenser	A rotating mechanical device very similar to a Generator. The Synchronous Condenser has no mechanical power input and cannot produce Real Power. It can only produce or absorb Reactive Power.
System Reliability	See “Reliability”.
Tap	An electrical connection where a new line is connected to an intermediate point on an existing transmission line and a new substation is connected to the end of the new line. A tapped configuration creates a single transmission circuit with more than two end points (for example, a “T”). A tapped configuration is less reliable than a looped configuration because a fault on any portion of the tapped circuit causes a complete loss of power to the new substation. Also, see Loop above.
Tap Changing Transformer	A Transformer that has the ability change the number of windings in service. By changing the number of windings in service (by moving to a different tap), the Tap Changing Transformer has the ability to maintain a nearly constant voltage at its output terminals even though the input voltage to the Transformer may vary.
Thermal Loading Capability	The current-carrying capacity (in Amperes) of a conductor at specified ambient conditions, at which damage to the conductor is non-existent or deemed acceptable based on economic, safety, and reliability considerations.
Thermal overload	A thermal overload occurs when electrical equipment is operated in excess of its current carrying capability. Overloads are generally given in percent. For example, a transmission line may be said to be loaded to 105 percent of its rating.
Thermal rating	See Ampacity.
Transformer	A device that changes the voltage of alternating

	current electricity.
Transformer Loading Capability	The current-carrying capacity (in Amperes) of a transformer at specified ambient conditions, at which damage to the transformer is non-existent or deemed acceptable based on economic, safety, and reliability considerations.
TSE	Transmission System Engineering.
Underbuild	A transmission or distribution configuration where a transmission or distribution circuit is attached to a transmission tower or pole below (under) the principle transmission line conductors.
Undercrossing	A transmission configuration where a transmission line crosses below the conductors of another transmission line, generally at 90 degrees.
VAr	One Volt ampere reactive. Also see the definition for MVAr.
Voltage	Electromotive force or potential difference.
Voltage Collapse	The point at which the reactive demand at a substation bus exceeds the reactive supply at that bus. When the reactive demand is greater than the supply, the voltage at that point in the system will drop. Eventually, the voltage will drop to a point at which it is no longer possible to serve load at that bus.
Wheeling	A service provided by an entity, such as a utility, that owns transmission facilities whereby it receives electric energy into its system from one party and then uses its system to deliver that energy to a third party. The wheeling entity is usually paid a fee for this service.
WSCC	Western Systems Coordinating Council

APPENDIX 1

Loss Analysis Calculations

LOCAL SYSTEM AFFECTS - Value of Loss Savings Calculations

	SYSTEM PEAK LOSS PRE-PROJECT (MW)	SYSTEM PEAK LOSS WITH POTRERO 7 UNITS (MW)	SYSTEM PEAK LOSS REDUCTION (MW)	PROBABILITY OF THE REDISPATCH SCENAIRIO	EQUIVALENT PEAK LOSS REDUCTION (MW)	SYSTEM ANNUAL LOAD FACTOR	EQUIVALENT HOURS LOSS FACTOR	ANNUAL ENERGY SAVED (GWh)	PROBABLE ANNUAL ENERGY SAVED (GWh)	ADJUSTMENT FACTOR FOR REMOTE DISPATCH	ADJUSTE PROBABI ANNUAI ENERGY SAVED (G\
Base Dispatch, PG&E Assesment 2004 Summer peak, Swing= Morro Bay unit 4. Potrero 7 units are off line.	889.24										
Dispatch 1, Local Adjustment : Potrero 7= +615 MW, Duke Moss= -352 MW, Helms= -263 MW		821.48	67.76	0.18	12.20	0.57	0.34	199.92	35.99	1.00	35.99
Dispatch 2, Local Adjustment : Potrero 7= +615 MW, Moss Landing= -615 MW		834.56	54.68	0.18	9.84	0.57	0.34	161.33	29.04	1.00	29.04
Dispatch 3, Local Adjustment: Potrero 7= +615 MW, La Paloma= -615 MW		831.25	57.99	0.18	10.44	0.57	0.34	171.10	30.80	1.00	30.80
Dispatch 4, Local Adjustment: Potrero 7= +615 MW, Pittsburg= -500 MW, Contra Costa= -115 MW		846.23	43.01	0.18	7.74	0.57	0.34	126.90	22.84	1.00	22.84
Dispatch 5, Local Adjustment: Potrero 7= +615 MW, Sutter= -525 MW, Riolinda= -90 MW		846.79	42.45	0.18	7.64	0.57	0.34	125.25	22.54	1.00	22.54
Dispatch 6, Remote Adjustment: Potrero 7= +615 MW, COI= -615 MW		787.57	101.67	0.10	10.17	0.57	0.34	299.97	30.00	0.50	15.00
Totals:				**1.00**	**58.03**				**171.21**		**156.21**
Average:			**61.26**					**180.74**			--

Energy Savings (GWh)	**156.21**		
Cost of Energy ($/MWh)	$36.00	Gas Cost	Heat Rate
Total Savings per year in 1000 ($)	**$5,623.49**	($/MMBtu)	(Btu/kWh)
Total Savings per year in million ($)	$5.62	**$3.00**	**12,000**
Number of Years	**20**		
Interest Rate (%)	**8%**		
Present Value of Savings in 1000 ($)	$55,212.25		
Present Value of Savings in million ($)	**$55.21**		

Energy Savings (GWh)	**156.21**		
Cost of Energy ($/MWh)	$52.00	Gas Cost	Heat Rate
Tot. Savings per year in 1000 ($)	**$8,122.82**	($/MMBtu)	(Btu/kWh)
Total Savings per year in million ($)	$8.12	**$4.00**	**13,000**
Number of Years	**20**		
Interest Rate (%)	**8%**		
Pr. Value of Savings in 1000 ($)	$79,751.03		
Pr. Value of Savings in million ($)	**$79.75**		